NATIONAL BUREAU OF STANDARDS REPORT

6938

PERFORMANCE TEST OF A "DUST-GARD"
THROW-AWAY TYPE AIR FILTER

by

Carl W. Coblentz and Paul R. Achenbach

Report to
Public Buildings Service
General Services Administration
Washington 25, D. C.

NBS

U. S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

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Air Conditioning, Heating, and Refrigeration Section
Building Technology Division

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1. Introduction

At the request of the Public Buildings Service, General Services Administration, the performance characteristics of a throw-away type air filter, identified by the trade name "Dust-Gard," were determined. The scope of this examination included determination of the arrestance of Cottrell precipitate, pressure drop, and dust-holding capacity at 370 ft/min face velocity of specimens with nominal thicknesses of 1 and 2 inches. As part of an investigation made by the National Bureau of Standards for the Department of Defense, the same performance examinations were also made at a face velocity of 540 ft/min.

2. Description of Test Specimens

The test specimens were supplied by the U. S. Gypsum Company, of Wabash, Indiana. The nominal size of these filters was 20 x 20 inches and 2 in. and 1 in. thick, respectively. The filter medium was made of glass fibers and held in a cardboard frame with channel-shaped cross section. The face of the filters was 17 5/8 in. square, offering a net face area of 2.16 square feet. The weight of the clean 2-in. filter was 482 grams and that of the 1-in. filter was 380 grams (17 oz and 13 1/2 oz, respectively). The filters were sprayed at the factory with an adhesive.

3. Test Method and Procedure

Arrestance determinations were made with the NBS "Dust Spot Test Method" using Cottrell precipitate as the aerosol. The test method is described in a paper entitled, "A Test Method for Air Filters," by R. S. Dill (ASHVE Transactions, Vol. 44, p. 379, 1938).

The filters were placed in a frame, sealed to prevent any by-pass of air, and then installed in the test apparatus. During the test, samples of air were drawn from the center points of the test duct 1 ft upstream and 8 ft downstream of the test specimen at equal rates and passed through known areas of Whatman No. 41 filter paper. The ratios of the upstream and downstream filter paper areas were selected to

obtain a similar increase of opacity. The change of opacity of these areas was determined with a sensitive photometer which measured the light transmission of the same spot on each sampling paper before and after the test. The two sampling papers used for each test were selected to have the same light transmission readings when clean. Air was drawn through both samplers while measured amounts of Cottrell precipitate were introduced into the test apparatus. The arrestance, A (in percent), was then computed by the following formula:

$$A = 100 - \frac{S_D}{S_D} \times \frac{\Delta D}{\Delta U} \times 100$$

where S_D and S_U are the respective downstream and upstream filter sampling paper areas and ΔD and ΔU the respective changes in opacity of the sampling papers. The aerosol used for the arrestance determination was Cottrell precipitate, which had been previously sifted through a 100-mesh wire screen. In order to simulate actual operating conditions when loading the filter, 4 percent by weight of No. 7 cotton linters, previously ground in a Wiley mill with a 4-millimeter screen, were introduced simultaneously with the Cottrell precipitate. Whereas the arrestance measurements were made with Cottrell precipitate only, the cotton linters were added during the loading process and a sufficient amount was included to obtain an overall weight ratio of 96 to 4 parts by weight, including that portion of Cottrell precipitate which was used for arrestance determinations.

Arrestance determinations were made at the beginning and at the end of the loading period for each filter at each face velocity. Also, additional arrestance determinations were made at selected intervals while the filter was being loaded.

The pressure drop across the filter under test was recorded at the beginning of the test and after each increment of 20 grams of Cottrell precipitate were introduced into the test apparatus. The filters were loaded with a dust concentration of approximately 1 gram per 1000 cu ft of air until the pressure drop reached 0.5 in. W.G. for the test conducted at 370 ft/min face velocity, and 0.8 in. W.G. for the test conducted at 540 ft/min face velocity.

4. Test Results

Tables 1 to 4 show the observed pressure drop, arrestance, and dust loads of the filters. The dust load per square foot net face area at the reported intervals is the weight of dust and lint introduced into the test apparatus, diminished by the fallout in the upstream portion of the test duct during that interval, divided by the net face area of the filter. The total fallout was determined at the end of each test by weighing the dust swept out of the upstream portion of the test duct. For computing the dust load per square foot net face area, the amount of dust and lint introduced into the test apparatus was multiplied by 1 minus the ratio of fallout to the total dust introduced, and divided by the net face area of the filter, according to the following formula:

$$L = \frac{D \times (1 - F)}{A}$$

where L = dust load, grams per square foot
D = dust and lint introduced, grams
A = net filter area, square feet
$F = \frac{\text{total fallout}}{\text{total dust and lint introduced}}$

The values shown in Tables 1 to 4 are graphically presented in Fig. 1 and 2, and smooth curves that approximate the curves of the least mean square distances of the individual points of observation have been fitted to the data. It will be noted that the dust-holding capacity, i.e., the dust load at final pressure drop, of the 1-in. filter was considerably lower than that of the 2-in. filter, at both air velocities, whereas the arrestances of both filters were similar. Table 5 summarizes the test results for both filter thicknesses and face velocities. The dust-holding capacity shown in this table is that dust load which, according to the graph or test results, was reached at the final pressure drop of 0.5 to 0.8 in. W.G., respectively. Also shown in this table are the mean arrestances for each filter under the various test conditions, during the period in which the capacity dust load was accumulated. These values were obtained by drawing horizontal lines through the arrestance curves in Fig. 1 and 2, which would give the same areas between the curves and the lines above and below.

The initial pressure drop increased from 0.086 in. W.G. across the 1-in. thick filter and 0.107 in. W.G. across the 2-in. thick filter to 0.156 in. W.G. and 0.196 in. W.G., respectively, with an increase in face velocity from 370 ft/min

to 540 ft/min, an increase of approximately 90 percent in each case. The dust-holding capacity of the 1-in. thick filter decreased from 190 g/sq ft to 173 g/sq ft when the air velocity was raised from 370 ft/min to 540 ft/min, whereas the dust-holding capacity of the 2-in. thick filter slightly increased, from 254 to 264 g/sq ft, with the increase of the face velocity.

The arrestance values determined for the clean filters ranged from 58 percent to 63 percent and increased from 77 to 79 percent when the filters were loaded to their final pressure drop. The average arrestance for all four test conditions was between 72 and 73 percent. Except for the increase of the arrestance value due to the dust load, which is to be expected with this type of filter, there was no significant difference of the arrestance in either of the test conditions.

Table 1

Performance of
U.S. Gypsum Co. "Dust-Gard" 1-in. Thick Air Filter
(Face Velocity, 370 ft/min. Aerosol, Cottrell Precipitate)

Dust Load g/sq ft	Pressure Drop in. W. G.	Arrestance %
0	0.086	-
4	0.091	58
57	0.194	72
110	0.304	75
154	0.411	77
190	0.505	78

Table 2

Performance of
U.S. Gypsum Co. "Dust-Gard" 1-in. Thick Air Filter
(Face Velocity, 540 ft/min. Aerosol, Cottrell Precipitate)

Dust Load g/sq ft	Pressure Drop in. W. G.	Arrestance %
0	0.156	-
4	0.164	63
60	0.357	70
117	0.535	77
173	0.800	79

Table 3

Performance of
U.S. Gypsum Co. "Dust-Gard" 2-in. Thick Air Filter
(Face Velocity, 370 ft/min. Aerosol, Cottrell Precipitate)

Dust Load g/sq ft	Pressure Drop in. W. G.	Arrestance %
0	0.107	-
4	0.110	61
48	0.186	72
92	0.245	75
136	0.296	75
180	0.357	76
251	0.492	78

Table 4

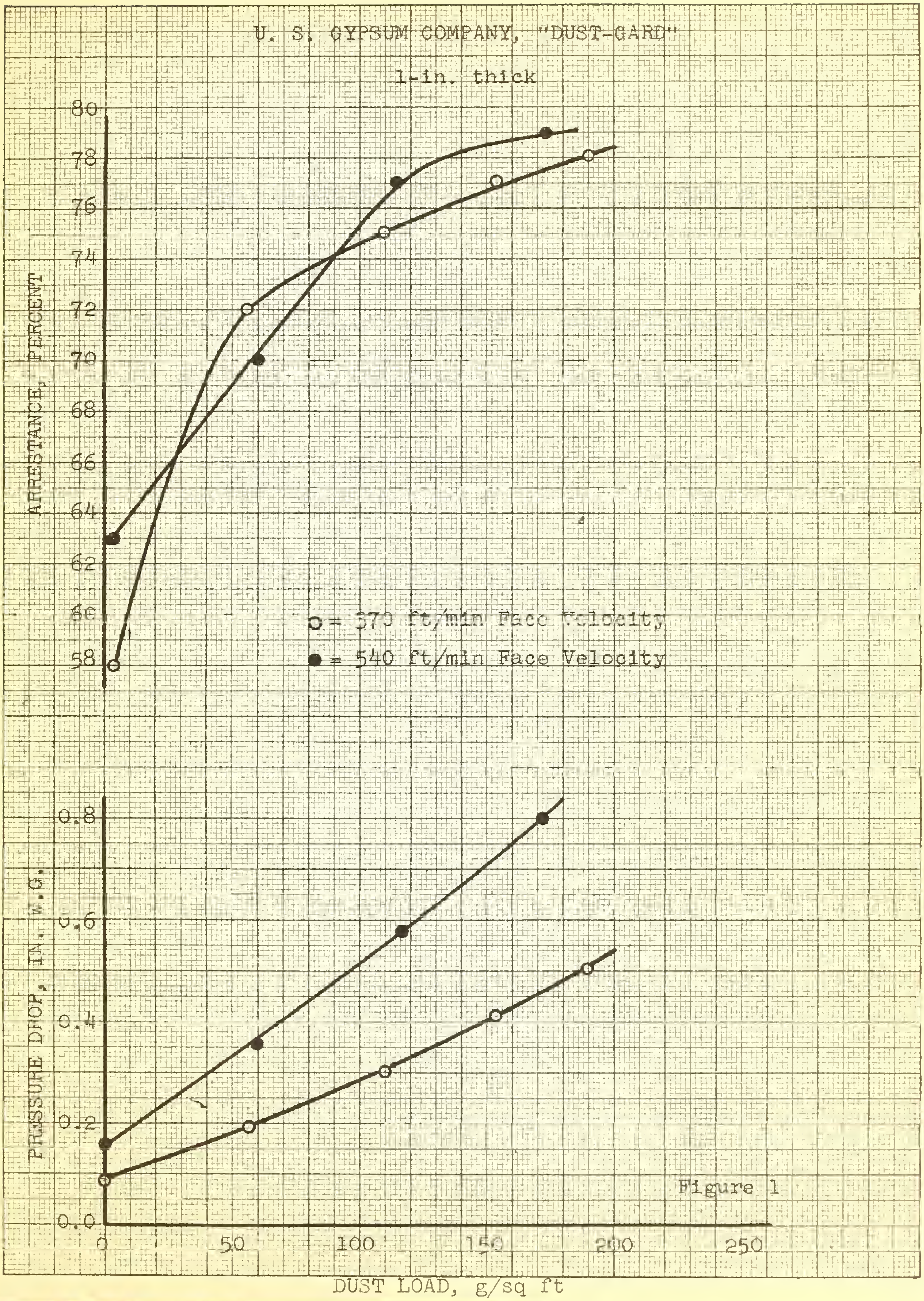
Performance of
U.S. Gypsum Co. "Dust-Gard" 2-in. Thick Air Filter
(Face Velocity 540 ft/min. Aerosol, Cottrell Precipitate)

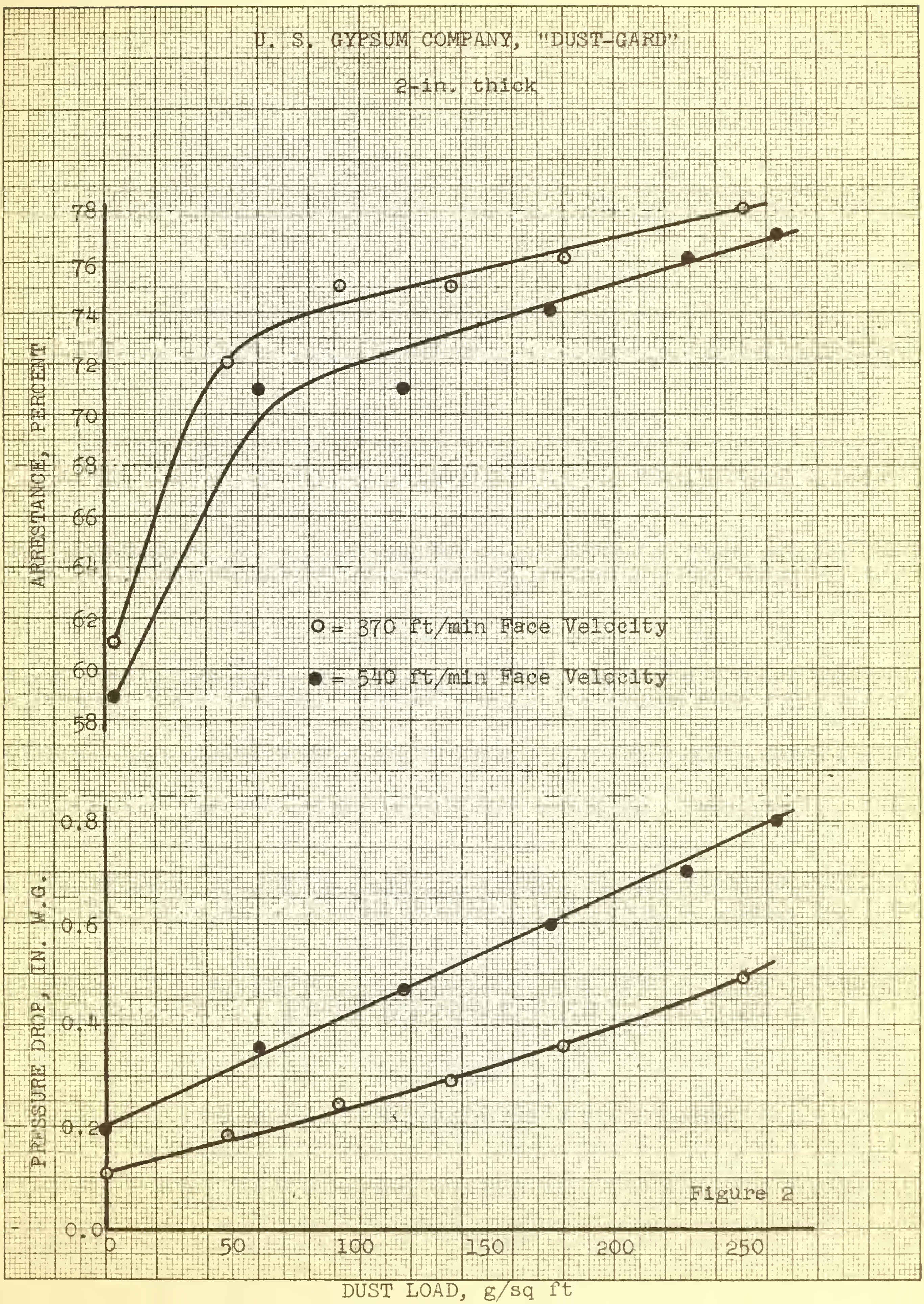
Dust Load g/sq ft	Pressure Drop in. W. G.	Arrestance %
0	0.196	-
4	0.203	59
60	0.357	71
117	0.469	71
175	0.594	74
228	0.699	76
264	0.801	77

Table 5

Summary of Test Results on
"Dust-Gard" Throw-away Air Filters

Thickness of Filter, inch	1		2	
Face Velocity, ft/min	370	540	370	540
Final Pressure Drop, in. W.G.	0.5	0.8	0.5	0.8
Initial Pressure Drop, in. W.G.	0.086	0.156	0.107	0.196
Dust-Holding Capacity, g/sq ft	190	173	254	264
Initial Arrestance, %	58	63	61	59
Average Arrestance, %	72	73	73	72
Final Arrestance, %	78	79	78	77


U. S. GYPSUM COMPANY, "DUST-GARD"
1-in. thick
ARRESTANCE, PERCENT
80
78
76
74
72
70
68
66
64
62
60
58
o = 370 ft/min Face Velocity
● = 540 ft/min Face Velocity
PRESSURE DROP, IN. W.G.
0.8
0.6
0.4
0.2
0.0
0
50
100
150
200
250
DUST LOAD, g/sq ft
Figure 1


U. S. GYPSUM COMPANY, "DUST-GARD"
2-in. thick
ARRESTANCE, PERCENT
78
76
74
72
70
68
66
64
62
60
58
○ = 370 ft/min Face Velocity
● = 540 ft/min Face Velocity
PRESSURE DROP, IN. W.G.
0.8
0.6
0.4
0.2
0.0
0
50
100
150
200
250
DUST LOAD, g/sq ft
BS-G 48 G
K&E CO., N.Y.
65216
Figure 2

U.S. DEPARTMENT OF COMMERCE
Frederick H. Mueller, *Secretary*

NATIONAL BUREAU OF STANDARDS
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THE NATIONAL BUREAU OF STANDARDS

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Electricity and Electronics. Resistance and Reactance. Electron Devices. Electrical Instruments. Magnetic Measurements. Dielectrics. Engineering Electronics. Electronic Instrumentation. Electrochemistry.

Optics and Metrology. Photometry and Colorimetry. Photographic Technology. Length. Engineering Metrology.

Heat. Temperature Physics. Thermodynamics. Cryogenic Physics. Rheology. Molecular Kinetics. Free Radicals Research.

Atomic and Radiation Physics. Spectroscopy. Radiometry. Mass Spectrometry. Solid State Physics. Electron Physics. Atomic Physics. Neutron Physics. Radiation Theory. Radioactivity. X-rays. High Energy Radiation. Nucleonic Instrumentation. Radiological Equipment.

Chemistry. Organic Coatings. Surface Chemistry. Organic Chemistry. Analytical Chemistry. Inorganic Chemistry. Electrodeposition. Molecular Structure and Properties of Gases. Physical Chemistry. Thermochemistry. Spectrochemistry. Pure Substances.

Mechanics. Sound. Mechanical Instruments. Fluid Mechanics. Engineering Mechanics. Mass and Scale. Capacity, Density, and Fluid Meters. Combustion Controls.

Organic and Fibrous Materials. Rubber. Textiles. Paper. Leather. Testing and Specifications. Polymer Structure. Plastics. Dental Research.

Metallurgy. Thermal Metallurgy. Chemical Metallurgy. Mechanical Metallurgy. Corrosion. Metal Physics.

Mineral Products. Engineering Ceramics. Glass. Refractories. Enameled Metals. Constitution and Microstructure.

Building Technology. Structural Engineering. Fire Protection. Air Conditioning, Heating, and Refrigeration. Floor, Roof, and Wall Coverings. Codes and Safety Standards. Heat Transfer. Concreting Materials.

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• Office of Basic Instrumentation. • Office of Weights and Measures.

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